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IMPROVED RAISED MICROSTRUCTURE OF SILICON BASED DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS:

Not Applicable.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT:

Not Applicable.

TECHNICAL FIELD:

The present invention relates to raised microstructures such as those found in pressure sensors, accelerometers and silicon based capacitive transducers and microphones. Specifically, the present invention is directed to improving the means of supporting a raised backplate of a silicon based capacitive transducer such as that found in a microphone.

BACKGROUND OF THE INVENTION:

The use of silicon based capacitive transducers as microphones is well known in the art. Typically, such microphones consist of four elements: a fixed backplate; a highly

compliant, moveable diaphragm (which together form the two plates of a variable air-gap capacitor); a voltage bias source and a buffer.

The two mechanical elements, the backplate and diaphragm, are typically formed on a single silicon substrate using a combination of surface and bulk micromachining well known in the art. One of these two elements is generally formed to be planar with the surface of the supporting silicon wafer. The other element, while itself generally planar, is supported several microns above the first element by posts or sidewalls, hence the term raised microstructure.

In general, the positioning of the two elements with respect to each other, affects the performance of the entire device. Intrinsic stresses in the thin films comprising the raised microstructure cause the structure to deflect out of the design position. In a microphone in particular, variations in the gap between the diaphragm and backplate affect the microphone sensitivity, noise, and over pressure response.

Many other factors also affect the manufacture, structure, composition and overall design of the microphone. Such problems are more fully discussed and addressed in U.S. Patent No. 5,408,731 to Berggvist; U.S. Patent No. 5,490, 220 to Loeppert, and U.S. Patent No. 5,870,482 to Loeppert.

In the specific example of the design of a microphone backplate as a raised microstructure, the goal is to create a stiff element at a precise position relative to the diaphragm. One method to achieve this is to form the backplate using a silicon nitride thin film deposited over a shaped silicon oxide sacrificial layer which serves to establish the desired separation. This sacrificial layer is later removed through well known etch processes, leaving the raised backplate. Intrinsic tensile stress in the silicon nitride backplate will cause it to deflect out of position. Compressive stress is always avoided as it causes the structure to buckle.

FIGURE 1 depicts one such raised microstructure **10** of the prior art. After the oxide is removed leaving the raised microstructure **10**, an intrinsic tension will be present within the plate **12.** This tension **T** results from the manufacturing process as well as from the difference between the coefficient of expansion of the material of the raised microstructure **10** and the supporting wafer **16.** As shown, the tension **T** is directed radially outwards. The tension **T** intrinsic in the plate **12** will result in a moment as shown by arrow **M** about the

base **18** of sidewall **14**. This moment **M** results in a tendency of the plate **12** to deflect towards the wafer **16** in the direction of arrow **D**. This deflection of plate **12** results in a negative effect on the sensitivity and performance of the microphone.

A number of undesirable means to negate the effects of this intrinsic tension within a thin-film raised microstructure are known in the prior art. Among them are that the composition of the thin film can be adjusted by making it silicon rich to reduce its intrinsic stress levels. However, this technique has its disadvantages. It results in making the thin film less etch resistant to HF acid, increasing the difficulty and expense of manufacture. An additional solution known in the prior art would be to increase the thickness of the sidewall supporting the raised backplate thereby increasing the sidewall's ability to resist the intrinsic tendency of the thin film to deflect. While this sounds acceptable from a geometry point of view, manufacture of a thick sidewall when the raised microstructure is made using thin film deposition is impractical.

It is an object of the present invention to overcome the disadvantages of the prior art with respect to the design of raised microstructures in silicon based devices by negating the undesirable effects of the intrinsic thin film tension inherent in said microstructure.

SUMMARY OF THE INVENTION:

It is an object of the present invention to provide an improvement to raised microstructures for use in silicon based devices. In accord with one embodiment of the present invention, a raised microstructure for use in a silicon based device is provided comprising a generally planar thin-film and a sidewall supporting the film, wherein the sidewall is ribbed.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

The raised microstructure of the present invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a cross sectional schematic of a raised microstructure known in the prior art;

FIGURE 2 is a cross sectional perspective view of a raised microstructure embodying the present invention;

FIGURE 3 is a cross section of the raised microstructure of FIGURE 2; and

FIGURE 4 is a plan view of FIGURE 2.

DETAILED DESCRIPTION OF THE INVENTION:

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiment illustrated.

An embodiment of the raised microstructure **10** of the present invention is shown in FIGURES 2 & 3. The raised microstructure **10** comprises a generally circular thin-film plate or backplate **12** supported by a sidewall **14**.

The raised microstructure **10** is comprised of a thin film plate **12** of silicon nitride deposited on top of a sacrificial silicon oxide layer on a silicon wafer **16** using deposition and etching techniques readily and commonly known to those of ordinary skill in the relevant arts. The sacrificial silicon oxide layer has already been removed from the figure for clarity. The sidewall **14** of the raised microstructure **10** is attached at its base **18** to the silicon wafer **16** and attached at its opposite end to the plate **12.** The sidewall **14** is generally perpendicular to plate **12**, but it is noted other angles may be utilized between the sidewall **14** and the plate **12.**

FIGURE 4 shows a plan view of the assembly of FIGURE 2 with a surface of the sidewall **14** of the present invention shown in phantom. It can be seen that the sidewall **14** of the present invention as shown in FIGURES 2-4 is ribbed, forming a plurality of periodic ridges **20** and grooves **22.** In the preferred embodiment, the ridges **20** and grooves **22** are parallel and equally spaced, forming a corrugated structure. Furthermore, the preferred embodiment utilizes ridges **20** and grooves **22** of a squared cross section. The effect of corrugating the side wall in this manner is to create segments **24** of the sidewall **14** that are radial, as is the intrinsic tension **T** of the plate **12.** By making portions of the sidewall **14**

radial, as is the tension **T**, the sidewall **14** is stiffened. It has been found that the sidewall **14** of the prior art, which is tangential to plate **12**, is easily bent as compared to the radial segments **24** of the present invention.

Other geometries than that shown in FIGURES 2-4 of the corrugations or ridges **20** and grooves **22** can be imagined and used effectively to increase the sidewall's **14** ability to resist moment **M** and the geometry depicted in the FIGURES 2-4 is not intended to limit the scope of the present invention.

For example, a generally annular geometry, generally triangular geometry or any combination or variation of these geometries or others could be utilized for the ridges **22** and grooves **24.**

In the preferred embodiment, the corrugations are radial and hence the sidewalls **14** are parallel to the tension in the backplate **12.** Furthermore, the sacrificial material is etched in such a way that the sidewalls **14** are sloped with respect to the substrate to allow good step coverage as the thin film backplate **12** is deposited.

While the specific embodiments and various details thereof have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention and the scope of protection is only limited by the following claims.